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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This TOP determines and measures the spurious responses of AM/FM radio receivers by using commonly available test instrumentation. It has general applicability to all receivers, including image, intermediate frequency (IF) feed-through, local oscillator related, and extraneously produced spurious responses. Spurious responses are signals propagated at frequencies outside of the tuned principal response frequency to which the receiver responds with measurable output power. They reveal frequencies where the receiver is most susceptible to undesired signals (jamming).		

US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105

12 May 1980

Test Operations Procedure 6-2-545

AD No. A086463

RADIO RECEIVER SPURIOUS RESPONSE

		<u>Page</u>
Paragraph 1.	SCOPE.	1
2.	FACILITIES AND INSTRUMENTATION	1
3.	PREPARATION FOR TEST	2
4.	TEST CONTROLS.	3
5.	PERFORMANCE TESTS.	6
6.	DATA REDUCTION AND PRESENTATION.	8

Appendices:

A.	Checklist.	A-1
B.	Data Collection Sheets	B-1
C.	Standard Test Conditions	C-1

1.0 SCOPE

These test procedures will determine and measure the spurious responses of AM and FM radio receivers by using basic, unsophisticated, commonly available test instruments and equipment. Spurious responses are signals with measurable output power propagated outside the principal tuned response region. Spurious responses reveal frequencies where the receiver will be most susceptible to undesired signals. They are responses of a receiver to single input frequencies only. They are usually generated when undesired signals mix with receiver local oscillators or their harmonics in nonlinear stages of the receiver. They consist of a family of related responses that can often be identified for single, dual and triple conversion receivers. These test procedures will have general applicability to all receiver spurious responses, such as image, intermediate frequency (IF) feed-through, local oscillator related, and those that are extraneously produced.

2.0 FACILITIES AND INSTRUMENTATION

The test item shall be placed in operating condition as outlined in the equipment Technical Manual.

2.1 Facilities

A communications test facility complete with benches equipped with basic ac power outlets, dc power supplies and appropriate terminals, leads, and connectors is required. The facility shall have an equipment pool and a shielded enclosure.

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<u>ITEM/CHARACTERISTICS</u>	<u>TOLERANCE</u>
Shielded Enclosure 100 or 120 dB as required	-5 dB, + ∞
Power Line Filter	-5 dB, + ∞
Line Voltage	+5 percent of nominal rms volts

2.2 Instrumentation

Must have a current calibration certificate. The generators shall either have at least 40 dB harmonic suppression or be backed by a tunable filter.

<u>ITEM/CHARACTERISTICS</u>	<u>TOLERANCE</u>
Signal Generator, Precision, variable frequency, amplitude modulated (AM), w/6 dB pad	+2 dB output level
FM Generator, Precision CW 0.1 to 1.0 volt	+2 dB output level
Power meter, or true rms volt-meter	+3 percent full scale reading
Input impedance matching network	+0.5 dB
Termination resistor for receiver audio output port (non inductive)	+0.5 percent of load impedance (ohms)

3.0 PREPARATION FOR TEST

3.1 Facilities

Assure facilities conform to minimum requirements.

3.2 Equipment

No specialized equipment required. Testing is conducted in a normal conditioned environment with the usual ancillary equipment.

3.3 Instrumentation

All instrumentation is to be set up in accordance with figure 1.

3.4 Characteristics Required (Technical)

Record the data on the parameters listed in appendix B.

3.4.1 Test Item

Serial number and nomenclature. Other data if required by test plan.

3.4.2 Instrumentation

Name, type/model, serial number, and calibration due date of each.

3.4.3 Personnel Data

Technician(s)' name(s), MOS/series, and title(s).

4.0 TEST CONTROLS At maximum AF gain, check for clipping; if found, reduce RF or IF gain.

a. Amplitude Modulation (AM) Receivers, Noise Limited (see figure 1).

(1) Use an IMPEDANCE MATCHING NETWORK to connect the input port of the receiver to the output port of the SIGNAL GENERATOR which will provide the specified source impedance, Z_s , to the receiver at the measurement frequency, f_o . If the signal generator output impedance equals Z_s , no matching network is required. Use thirty percent modulation at 1000 Hz at each measurement frequency.

(2) Connect the TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_L , and a power rating in excess of the receiver's rated audio output power level to the audio output port of the receiver. Connect the TRUE RMS VOLTMETER across this resistor. Measure $E_o = \sqrt{P_o R}$, P_o is the rated output.

OR, Connect the POWER METER having an input impedance equal to the specified load resistance, R_L , to the audio output port of the receiver.

(3) Set the signal generator to zero output and adjust the receiver AF gain to produce 25 percent of P_o . This is noise power only. Adjust the output level of the signal generator to give P_o = full receiver output power. This is 25 percent noise and 75 percent audio signal, and equals a 6 dB signal-plus-noise to noise (SN/N) ratio. Measure the open circuit signal voltage E_i at the signal generator output (or impedance net). This is the 6 dB sensitivity E_i of the receiver at that reference frequency, f_o . Leave the receiver as set.

(4) Adjust the output level of the signal generator to maximum 100,000 to 1,000,000 microvolts as the receiver is being slowly detuned.

12 May 1980

(5) Slowly tune the GENERATOR FREQUENCY away from the principal response region, and search for spurious response from the receiver's output. Designate the spurious frequency as f_s .

(6) Reduce the GENERATOR OUTPUT, when a response is found, to the reference audio output power, P_o . The 6 dB SN/N sensitivity, E_s , is the open circuit output voltage of the generator at that power.

(7) Determine the frequency, f_s , in kilohertz or megahertz, and the open circuit signal voltage, E_s , in microvolts, at the OUTPUT TERMINAL of the matching network, if used; otherwise, at the output terminals of the generator.

(8) Calculate the ratio, $R(S)$, in decibels by the following equation:

$$R(S) = 20 \log \frac{E_s}{E_1}$$

$R(S)$ is the spurious response attenuation of the receiver, referenced to the receiver's 6 dB SN/N sensitivity (E_1), at frequency f_s .

(9) Repeat steps 4a(3) through 4a(8) until the desired frequency range is covered.

b. AM Receivers, Gain Limited (see figure 1). The reference sensitivity is the measure of total gain for the tuned frequency and for spurious frequencies. Using $E_o = \sqrt{P_o R}$, calculate E_o , the receiver output voltage for P_o , rated output power. Modulate at f_o receiver frequency with 1000 Hz and 30 percent. Adjust the signal generator output to give the receiver's rated voltage/power (E_o/P_o) ratio. Read the open circuit generator output voltage E_s , the receiver sensitivity. Repeat this procedure at all other measurement frequencies and for all spurious responses. Record as in 6 dB SN/N sensitivity reference ratio.

c. Frequency Modulated (FM) Receivers (see figure 1).

(1) For FM receivers a continuous wave (CW) unmodulated signal generator is required to determine the reference 20 dB level quieting sensitivity. This method holds for one or more limiters.

(2) Use an IMPEDANCE MATCHING NETWORK to connect the input port of the receiver to the output port of the SIGNAL GENERATOR and to provide the specified source impedance, Z_s , to the receiver at the measurement frequency, f_o . If the signal generator output impedance equals Z_s , no matching network or attenuation pad required.

(3) Connect a TERMINATION RESISTOR having a resistance equal to the specified load resistance, R_L , and a power rating in excess of the receiver's rated audio output power level to the audio output port of the receiver. Connect the TRUE TMS VOLTMETER across this resistor.

OR, Connect a POWER METER, having an input impedance equal to the specified load resistance, R_L , to the audio output port of the receiver.

(4) Set the VOLTMETER on a range to indicate 25 percent of the rated output power, P_O . The voltage to be measured is given by the equation:

$$E_O = \sqrt{1/4 P_O R_L}$$

Example: If $P_O = 50$ W and $R = 50$ ohms for 25 percent P_O , $E_O = \sqrt{1/4 \cdot 50 \times 50} = 25$ Vrms Watts = $E^2/R (25)^2/50 = 625/50 = 12.5$ W = $0.25 P_O$.

OR, Set the POWER METER on a range to indicate 25 percent of the rated output power, P_O , or 12.5 watts.

(5) Measure the 20 dB QUIETING SENSITIVITY, the receiver reference, by tuning the receiver and signal generator to the measurement frequency, f_o , using the setup in figure 1. The signal is unmodulated.

(6) The measurement of the reference:

(a) Reduce the generator output to zero and adjust the receiver AF gain to deliver 25 percent of P_O on the meter or E_O on the voltmeter. Increase the output of the signal generator to reduce the audio (noise) level to 0.25 percent of P_O ($0.0025 P_O$). This generator output produces a noise level 20 dB below the 25 percent P_O level and is the 20 dB quieting reference.

(b) Leave the AF gain as set for the reference and raise the generator open circuit output level to 100,000 to 1,000,000 microvolts.

(7) Slowly tune the GENERATOR FREQUENCY away from the principal tuned response region, and search for a spurious response frequency at the receiver output.

(8) Reduce the GENERATOR OUTPUT when a spurious response frequency is found to give the 20 dB of noise quieting.

(9) Determine the spurious frequency, f_s , in kilohertz or megahertz, and the open circuit signal voltage, E_s , in microvolts, at the output terminal of the matching network, if used; otherwise, at the output terminals of the generator.

(10) Calculate the ratio, $R(S)$, in decibels by the following equation:

$$R(S) = 20 \log \frac{E_s}{E_1}$$

$R(S)$ is the spurious response attenuation of the receiver, referenced to the receiver's 20 dB quieting sensitivity (E_1) at the frequency, f_s .

(11) Steps 4c(4) through 4c(10) shall be repeated until the desired frequency range band is covered. Use f_o , f_o' , f_o'' for the tuned frequencies.

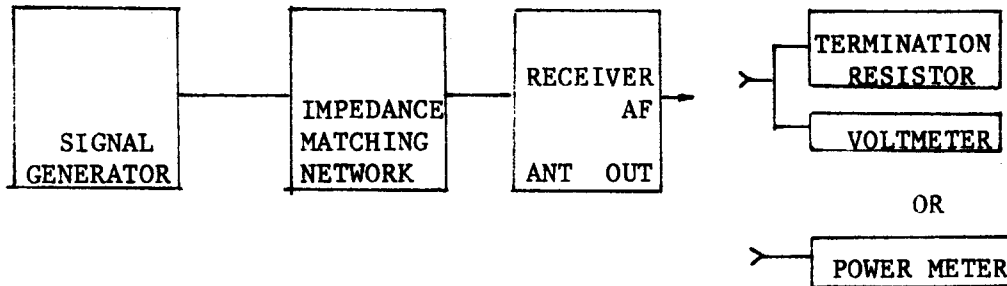


Figure 1. Test setup for spurious response (AM, FM sensitivity)

5.0 PERFORMANCE TESTS

5.1 Data Required

a. Record the following for AM receivers (appendix B):

(1) The measurement frequency, f_o , in kilohertz or megahertz, to which the receiver is tuned.

(2) The frequencies, f_s , in kilohertz or megahertz, that cause a spurious response.

(3) The value of the source impedance Z_s , in ohms, connected to receiver input port.

(4) The value of termination resistance, R_t , in ohms, connected to receiver audio output terminals.

(5) The output voltage, E_o , in volts.

OR, Reference output power, P_o , in watts.

(6) The 6 dB SN/N sensitivity, E_1 , in microvolts.

(7) The open circuit voltages, E_s , in microvolts, at the output terminals of the matching network, if used; otherwise, at the output terminals of the generator. These are the spurious response frequency voltages.

(8) The spurious response attenuation, $R(S)$, in decibels, for each spurious response.

b. Record the following for FM receivers (appendix B):

(1) The measurement frequency, f_o , in kilohertz or megahertz, to which the receiver is tuned.

(2) The frequencies, f_s , in kilohertz or megahertz, that cause the spurious response.

(3) The value of the source impedance, Z_s , in ohms, connected to receiver input port.

(4) The value of termination resistance, R_t , in ohms, connected to receiver audio output terminals.

(5) The OUTPUT VOLTAGES, E_o , and $0.1 E_o$, in volts.

(6) The MEASURED OUTPUT POWERS, $0.25 P_o$ and $0.0025 P_o$, in watts.

(7) The 20 dB QUIETING SENSITIVITY, E_1 , in microvolts.

(8) The open circuit voltage, E_s , in microvolts. This is the spurious response frequency 20 dB quieting sensitivity.

(9) The spurious response attenuation, $R(S)$, in decibels, for each spurious response frequency found.

5.2 Method

By obtaining the required data from the outlined procedural controls, the calculation of spurious response attenuations for specific frequencies and single, dual, or triple conversion receivers can be performed.

6.0 DATA REDUCTION AND PRESENTATION

6.1 Data Reduction

6.1.1 Computations to determine the receiver sensitivity.

6.1.1.1 AM and FM Receivers

For AM noise limited receivers, use the 6 dB SN/N reference and for FM receivers, use the 20 dB QUIETING SENSITIVITY as a reference. For gain limited AM receivers use a TOTAL GAIN figure.

6.2 Data Presentation

a. Table of spurious response levels at other frequencies than the tuned receiver frequencies; i.e., outside the band.

b. Charts may be used to show the variation of E_1 , f_s , and $R(S)$ with receiver frequency.

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APPENDIX A. RADIO RECEIVER SPURIOUS RESPONSE CHECKLIST

Facility conforms to minimum requirements.

Instrumentation in calibration.

Instrumentation data recorded.

Name and MOS of person taking data recorded.

Test item data recorded.

Cable attenuation known.

Impedance of test setup measured.

Matching pads required.

Thermal equilibrium obtained.

Output voltage/power measured.

Data reduced.

Temperature Record (Daily) in log:
(for field testing)

Initial

Final

Deviations

12 May 1980

TOP 6-2-545

APPENDIX B

Date

SAMPLE FORM SPURIOUS RESPONSE DATA SHEET
For AM or FM Receivers (cross one out)

Test Item _____ Serial No. _____

Other Characteristics* _____

R(S) in dB	Receiver Spur.		Ohms Z_s	Ohms R	Volts/Watts E_o/P_o^{**}	Micro-	Micro-
	Freq. f_o	Freq. f_s				volts E_i	volts E_s

*List instruments on separate sheet.

**For FM receivers, record $E_o/0.25 P_o$ and $0.1 E_o/0.0025 P_o$.

Temperature
(Daily)

Initial:
Final:
Change:

Signature _____
Title _____

APPENDIX C. STANDARD TEST CONDITIONS

1.0 GENERAL

a. Certain test conditions apply to the majority of these procedures and therefore can be "standardized." Deviations from these standard conditions occur in specific instances, and these are made clear in the appropriate section.

b. These standard test conditions are recommendations only, and may be modified according to the needs of a particular measurement situation. When this is done, the prevailing test conditions should be recorded with the test data so that proper account can be taken thereof, in the interpretation of the measurement results.

2.0 AMBIENT CONDITIONS

2.1 STANDARD TEMPERATURE

Standard temperature shall be +20°C to +35°C.

2.2 STANDARD RELATIVE HUMIDITY

Standard relative humidity shall be as follows:

a. Zero to 90 percent at 20°C to 30°C.

b. Zero to 79 percent at 30°C to 35°C.

2.3 STANDARD ATMOSPHERIC PRESSURE

Standard atmospheric pressure shall be the ambient atmospheric pressure at the time of the test.

3.0 PRIMARY INPUT POWER SUPPLY VOLTAGE

Standard input power supply voltage shall be within +5 percent of the mean of the rated operating voltage range of the receiver, as given in the manufacturer's specifications.

4.0 ELECTROMAGNETIC COMPATIBILITY CONDITIONS

These tests shall be conducted, as far as practicable, in areas that are sufficiently free from electromagnetic interference fields to allow the measurements to be made without significant adverse effect on the results. Primary input power sources shall be sufficiently filtered to accomplish the same end. The rudimentary test instrumentation shall be properly shielded, filtered, and grounded so as to minimize erroneous results caused by extraneous signals from these or other sources.

5.0 RECEIVER PREPARATION

5.1 OPERATING CONDITIONS

When important to the test results, the receiver setup should be situated so that it closely approximates the physical and electrical conditions in which it is intended to operate. All accessories that may affect test results shall be installed and put into operation.

5.2 RECEIVER CONDITION

Before any measurements are performed, the receiver shall be in proper operating condition as stated in paragraph 2.0, page 1 of the main text.

5.3 WARM-UP TIME

Sufficient warm-up time, e.g., from one-half to two hours, shall be provided before any measurements are performed to insure an adequate stabilization of the receiver parameters.

6.0 PREPARATION OF TEST INSTRUMENTATION

6.1 OPERATING CONDITIONS

Test instruments shall be operated according to the manufacturer's instructions. Check for proper grounding, proper connections of cables and probes, and proper shielding, filtering, and isolation as required. Sufficient warm-up time shall be provided to insure stable operation.

6.2 CALIBRATION

All test equipment must meet the manufacturer's specifications on accuracy and other performance parameters. Information on accuracy, frequency response, spectral purity, etc., must be verified and at hand in order to obtain useable results from these tests.

7.0 TERMINATIONS

All terminations to receiver terminals (ports) shall be of the proper impedance and power rating, as specified by the receiver manufacturer. They shall be adequately shielded to prevent interference to and from other parts of the measurement system.

8.0 TEST FREQUENCIES

No standard test frequencies are stated in this TOP. As written, the discussion covers any frequency the receiver can respond to, however the Test Plan will define the number of tests to be run; each shall be treated as described and complete data recorded. Generally high, middle, and low frequencies in the receiver band are desirable.

9.0 SIGNAL LEVELS

9.1 INPUT SIGNAL VOLTAGE

a. No standard input signal level is specified in this TOP. When a specific level is required for a particular test, it is so stated in that test procedure.

b. RF input signal levels are expressed in terms of the open circuit voltage across the output terminals of the source of the input signal. If an impedance matching, filter, or attenuating network is used between the signal generator output terminals and the receiver input terminals, the input signal level is the open circuit voltage across the output terminals of the network. If no such network is used, the input signal is the open circuit voltage across the output terminals of the generator.

10. AUDIO OUTPUT POWER

The reference value for the receiver's audio output power level shall be one of the following:

- a. Twenty-five percent of manufacturer's rated audio output power.
- b. Maximum audio output power having a 12 dB SINAD signal plus noise plus distortion, divided by noise plus distortion, $S+N+D/N+D$ (SINAD) ratio (6.3 percent noise and distortion).
- c. Manufacturer's rated audio output power.
- d. If other levels are used, state the basis for the output power in the report.